#J
15 6/10/99

BOX PATENT APPLICATION

OIPE JC60
FEB 0 9 1999
PATENT & TRADEMARK OFFICE

PATENT

Agent's Docket No. 95443-US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

RECEIVED
FEB 1 1 1999
Group 2700

In re Application of Natalie Giroux et al)
)
Serial No.: 09/199,786) Art Unit: 2756
)
Filed: 11/25/98) Ex:

For: CONTROLLING ATM LAYER TRANSFER CHARACTERISTICS BASED ON PHYSICAL LAYER DYNAMIC RATE ADAPTATION

February 8, 1999

Commissioner of Patents and Trademarks

Washington, D.C. 20231

TRANSMITTAL LETTER

SUBMISSION OF CERTIFIED COPIES OF PRIORITY APPLICATIONS IN SUPPORT OF CLAIM TO PRIORITY UNDER 35 USC 119

Sir:

Submitted herewith are the following documents:

Certified copies of Canadian Patent Application No. 2,222,934 and Canadian Patent Application No. 2,240,596.

Respectfully submitted,

BY: ____________________
George M. MacGregor
Reg. No. 37547
Agent of Record

MARKS & CLERK
P. O. Box 957, Station B
Ottawa, Ontario Canada K1P 5S7 (613) 236-9561

OPIC
OFFICE DE LA PROPRIÉTÉ INTELLECTUELLE DU CANADA

CIPO
CANADIAN INTELLECTUAL PROPERTY OFFICE

Bureau canadien des brevets

Canadian Patent Office

Certification

La présente atteste que les documents ci-joints, dont la liste figure ci-dessous, sont des copies authentiques des documents déposés au Bureau des brevets.

Certification

This is to certify that the documents attached hereto and identified below are true copies of the documents on file in the Patent Office.

Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,222,934**, on November 28, 1997, by **NEWBRIDGE NETWORKS CORPORATION**, assignee of Ben Bacque and Natalie Giroux, for "Controlling ATM Layer Transfer Characteristics Based on Physical Layer Dynamic Rate Adaptation".

S. Grégoire
Agent certificateur / Certifying Officer

January 21, 1999
Date

Abstract

A system and method for managing data traffic through a path that includes a transmission link having a transport rate that is subject to change with time. The data traffic is shaped to ATM Forum's available bit rate (ABR) category of service. ABR traffic has an integrated resource management (RM) cell that returns congestion related information to the source over a feedback path. With this congestion information the source is able to tailor its traffic send rate in order to accommodate any reduced transport rate encountered by the traffic due to dynamically changing rate over the transmission link.

CONTROLLING ATM LAYER TRANSFER CHARACTERISTICS BASED ON PHYSICAL LAYER DYNAMIC RATE ADAPTATION

Field of the Invention

This invention relates to communications service over an asynchronous transfer mode (ATM) network and more particularly, to management of data traffic over an end-system to end-system path which includes an ATM layer connection and a physical layer link having a transfer rate subject to variation as a function of time. Transfer characteristics provided by the network for the ATM layer connection are controlled based on dynamic adaptation to the physical layer rate variation of the link.

Background

Asynchronous transfer mode (ATM) technology is rapidly becoming the technology of choice for broadband digital communications. The characteristic fixed length ATM cell is well suited to the transport of multi-media communications including voice, video and data. As a result, ATM technology supports a wide variety of services and applications. The ability of ATM technology to adapt to existing systems and architectures results in improved performance and bandwidth utilization. This has resulted in

the integration of ATM architectures with other developing technologies in order to gain the advantages offered by ATM.

The rapid expansion of Internet connections and services in recent years has resulted in attempts to increase the physical layer transfer rate, otherwise referred to herein as the transport rate, over existing telephone connections. Although coaxial cable or optical fiber is being used for trunk connections between central offices, connections to private homes and small businesses rely on existing local loops. These, of course, have a limited bandwidth and attempts to improve utilization of this bandwidth are being investigated constantly.

One of the technologies which will improve transport rate over that obtained by presently used modems and ISDN lines is known as asymmetric digital subscriber loop (ADSL). The asymmetric loop provides a higher transport rate in the downstream (i.e. to the ADSL subscriber) direction than it does in the upstream (i.e. from the ADSL subscriber) direction. The range of downstream transport rate is 1.5 to 8 mbps whereas the upstream rate is 9.0 to 640 kbps. This downstream rate offers considerable improvement over the 160 kb/s rates provided by existing ISDN architectures.

As the potential transport rate increases, minor variations in the local loop as a function of time become

significant. The transport rate within the above-mentioned range in ADSL technology is known to vary due to physical conditions of the local loop. These physical conditions include the actual condition of the loop itself, temperature variations and/or electromagnetic interference. Therefore, conventional ADSL termination units, also commonly referred to as ADSL modems, are equipped with dynamic rate adaptation functionality whereby the modem dynamically adjusts its transmission rate according to the measured physical characteristics (i.e., usable transport rate) of the loop. The transmission rate in use by the ADSL modem is stored in an internal register which may be read by an end-system connected to the modem.

Currently, the proposed broadband ADSL service interface with an ATM network utilizes unspecified bit rate (UBR),one of the five categories of service defined in the ATM Forum's Traffic Management Specification, version 4.0. This service category is intended for non-real time applications such as those that do not require tightly constrained delay and delay variations. UBR service does not specify traffic related service guarantees. Under UBR service a peak cell rate (PCR) is negotiated between the source and destination at connection setup. This rate is negotiated based on known physical characteristics of the

ADSL link at the time the connection through ATM network is established. The source will continue to send data at the negotiated PCR until a new PCR is negotiated.

As indicated previously, the transmit rate characteristics of the ADSL link forming part of the path between the two end-systems may change during the time of the connection (i.e. after the connection has been set up). If, for example, the transport rate decreases during this interval the ADSL link will not be able to carry the data at the transmission rate of the source. As a result, congestion will occur at the interface between the ATM path and the ADSL link leading to packet discard and a reduction in system performance.

Another network architecture in which a transmission link may have a variable transport rate is in a wireless configuration. In this example, the data is transmitted from the ATM network interface card to the destination across a wireless link. Such wireless links are subject to transport rate variations due to atmospheric conditions changing path lengths, etc. Again, if the transport rate characteristic is reduced after the connection has been negotiated, congestion will occur.

A third example of a transmission link having a dynamically varying transport rate is an inverse

multiplexing over ATM (IMA) system. In this example, one of the multi paths through the network may experience a temporary failure which necessitates the remaining paths to increase their bandwidth requirements. If the connections are already operating at or near their physical capacity they will be unable to satisfy the negotiated PCR resulting in congestion.

One possible solution is for the two end-systems to renegotiate the PCR for the ATM connection but such is problematic in that the re-negotiation process is very slow and consequently congestion may increase to the point where data is discarded.

On the other hand, if the transport rate capacity increases after the connection has been negotiated, congestion will not be a problem. In this case, however, bandwidth capacity is wasted in that the system is not operating at its maximum capacity.

There is, therefore, a requirement to improve the management of data traffic through an ATM path that includes a link having a dynamically variable transport rate.

Summary of the invention

Therefore, in accordance with a first aspect of the present invention there is provided in a communications

network for the transport of data between a source and a destination over an ATM path which includes a transmission link having a transport rate which is subject to variations as a function of time, a method of managing data traffic through the network. The method comprises: shaping data connections from the source in accordance with the ATM available bit rate (ABR) category of service, the ABR connection including integrated resource management cells for carrying congestion information back to the source over a feedback path; monitoring dynamically the transport rate of the transmission link and recording the transport rate in the RM cell; returning the RM cell including the recorded dynamic transport rate of the transmission link to the source; and adjusting the send rate of the source in accordance with the transport rate information.

In accordance with a second aspect of the present invention there is provided a system for managing data traffic between a source and a destination over an ATM path, the ATM path including a transmission link having a dynamically variable transport rate. The system comprises shaping means in the source to shape the data traffic connection to comply with ATM available bit rate category of service, the ABR connection including an integrated resource management cell for returning explicit rate congestion

information to the source over a feedback path; monitoring means associated with the transmission link to monitor dynamically, transport rate capability of the transmission link; recording means in the monitoring means to record the transport rate capability in the RM cell; and control means in the source to change the send rate of the data traffic in accordance with the transport rate information.

The invention advantageously associates the instantaneous physical layer information on transmission rates with the ATM layer congestion information.

Brief Description of the Drawings

The invention will now be described, by way of exemplary embodiments, in greater detail with reference to the attached drawings wherein:

Figure 1 illustrates an ATM system including an ADSL link;

Figure 2 illustrates an ABR connection with resource management cells;

Figure 3 is a flow chart of the ABR service combining physical layer rate information with ATM layer traffic load;

Figure 4 illustrates the system of Figure 3 for bi-directional traffic;

Figure 5 illustrates a variation of the network shown in Figure 3;

Figure 6 illustrates a further variation of the network of Figure 3;

Figure 7 is an illustration of an ATM network including a wireless link; and

Figure 8 illustrates an ATM network with an IMA connection.

Detailed Description of the Invention

Turning to Figure 1, illustrated is an exemplary client-server based data processing system comprising an ATM network 10, communicatively coupled to which are two conventional end-systems 11 and 12. End-system 11 is embodied by a data server 13 connected through an ATM network interface card (NIC) 14 to the ATM network 10. End-system 12 is embodied by a client 15 connected through an ADSL link 16 and ATM termination unit 17 to the ATM network 10. The ADSL link 16 is constituted by two ADSL modem 18 and 19, with which the client 15 and ATM termination unit 17 are respectively equipped and which are interconnected by a typical subscriber loop 20.

Bi-directional data traffic, identified as upstream and downstream in Figure 1, is exchanged between the two end-systems 11 and 12. With respect to upstream traffic, the client 15 (end-system 12) and server 13 (end-system 11) are the source and destination, respectively. However, for

downstream traffic, server 13 (end-system 11) is the source and the client 15 (end-system 12) is the destination.

The ATM termination unit 17 interfaces traffic to and from the ATM network 10 with the ADSL link 16, and includes a buffer 21 for managing egress of downstream traffic onto the link 16. An example of the ATM termination unit 17 is an access node or digital subscriber loop access multiplexer (DSLAM). The ATM termination unit 17 together with the ATM NIC 14 are responsible for shaping ATM layer traffic between their respective end-systems 12 and 11.

Under current proposed schemes, in respect of downstream traffic, data from source end-system 11 is shaped to comply with the ATM Forum's unspecified bit rate (UBR) category of service. This means that at connection setup source end-system 11 and destination end-system 12 negotiate a data transport rate which represents the peak cell rate which the system can accommodate at that time. Once negotiated the peak cell rate remains constant until the connection is torn down or a new transport rate is negotiated.

ADSL link 16 represents a copper local loop 20 commonly found in private homes and small businesses. It is known that the physical characteristics of ADSL link 16 may change with time due to the physical condition of the link,

temperature variations or electromagnetic interference. If the physical characteristic of the loop 20 changes such that the peak cell rate carried by the ADSL link 16 is reduced after the connection has been negotiated, ADSL link 16 will not be able to carry all of the data traffic sent out from source end-system 11. In this case, buffer 21 will become full and a congestion condition will result. Eventually buffer 21 will overflow resulting in cell traffic discard and loss of continuity.

According to the present invention this problem is overcome by shaping traffic from source 12 to comply with the ATM Forum's available bit rate (ABR) category of service. As shown in Figure 2, ABR class traffic typically includes data cells 28 and resource management (RM) cells 26 integrated into the traffic flow from source end-system 11. Each network element 24 along the path within the ATM network monitors its local congestion conditions and may mark the resource management cell with an indication of bandwidth availability through that element. When the resource management cells reach destination end-system 12 they are returned towards the source end-system 11 along feedback path 30. Each RM cell, passing back through the network elements 24 receives updated congestion information and returns to the source end-system 11 with an explicit

rate (ER) of the available bandwidth or the peak cell rate permitted by the source.

Conventional ER implementations are designed to function with constant speed links carrying variable loads or data traffic. The ER methodology, according to this invention, handles variable rate links along with variable load. A quick convergence to the available or usable bandwidth of a particular variable rate link is desired, and the use of physical layer information about the instantaneous transmission rate of the link achieves increased convergence speed.

Figure 3, in conjunction with reference to Figure 1 illustrates the manner in which the ABR category of service is implemented in the present invention. Downstream data traffic egressing from source end-system 11, specifically server 13 is shaped to comply with the ABR category of service. Starting at step S1, the ATM termination unit 17 receives an RM cell, responsive to which the destination end-system 12 determines the instantaneous physical layer rate of the ADSL link 16, at step S2. Such is effected by the ADSL modem 19 measuring the physical layer rate over the loop 20 in a conventional manner and providing the measured physical link rate in an internal register, from which this information is retrieved by the ATM termination unit 17.

The ATM termination unit 17, at step S3, then computes a new allowed cell rate (ACR) as a function of measured ATM layer bandwidth fair sharing, local to unit 17, and the measured instantaneous physical rate of the ADSL link 16. At step S4, the ER value in the received RM cell is compared to the computed ACR. If the ACR is less than that ER, step S5, then the computed ACR is inserted as the new ER parameter in the RM cell, and otherwise advance directly to step S6. Lastly, at step S6, The RM cell of the ABR traffic is returned to the source end-system 11 in order to appropriately modify the send rate of traffic leaving source end-system 11. Thus, if the physical characteristics of ADSL link 16 between the ATM termination unit 17 and destination client 15 changes during the time of the connection, the ACR is now derived from the transport rate (i.e. less than or equal to transport rate) recorded in the ER field of the RM cell and is returned to ATM NIC 14 of the source end-system 11 over the feedback path, thereby shaping the downstream traffic. Consequently, previously occurring congestion problems are avoided.

Traffic management for the ATM based system in Figure 1 has been described thus far having regard to downstream traffic, for which the ABR service class has been used to shape traffic dependent upon the physical layer transmission

rate of the ADSL link 16. Of course, ABR may be used to shape the upstream traffic as well. However, some network level efficiencies may be realized by employing a different class of service, either ABR or UBR, for each direction of such bi-directional traffic. Figures 4 to 6 depict various end-system configurations and the preferred service classes to be used.

Figure 4 relates to bi-directional traffic flow between end systems 40 and 41. In the downstream direction traffic from source end-system 40 to destination end-system 41 is shaped to conform to the ABR category of service as explained above. If, however, traffic is flowing in the upstream direction from source end-system 41 towards destination end-system40, the change in physical characteristics of ADSL link 42 will not lead to downstream congestion. In this case, traffic may be shaped by the ATM termination unit 43 to the UBR category of service for the reverse direction.

It is noted that the UBR class of service does not transfer resource management cells between end systems, whereas the ABR class of services provides for RM cells in both directions. Consequently, employment of ABR service for downstream traffic (i.e., from end system 40 to end system 41) and UBR service for upstream traffic (i.e., from

end system 41 to end system 42) achieves a more efficient utilization of network bandwidth resources because of less overhead and lower probability for congestion.

Figures 5 and 6 illustrate different network architectures in which at least a portion of the bi-directional path between end systems 40 and 41 includes an ADSL link 42. As shown in Figure 5 the path includes optical fiber 44 providing an OC3 link between an access switch 45 of the ATM network 46 and the termination unit 43 which includes ABR interface 47 and UBR interface 48. As in the previous example downstream traffic from end system 40 to end-system 41 is shaped to conform to ABR category of service whereas upstream traffic from end system 42 to termination unit 43 may comply with UBR category of service. It is, of course, within the scope of the invention to shape traffic in accordance with ABR category of service in both directions. Figure 6 is yet a further example in which the ADSL link is between two ATM networks. As in previous examples, traffic from end source to end source is shaped to ABR but may be shaped to UBR within the network at the interface to the ADSL link 20.

As indicated previously, the ADSL link represents one example wherein physical characteristics of the path may change dynamically to alter the transport rate capabilities.

Figure 7 represents a further example incorporating a wireless path. In this example, virtual destination 50 represents the termination unit for ATM traffic. Destination 52 is configured to received data traffic from virtual destination 50. Traffic between the destination 52 and virtual destination 50 is carried through a wireless path from transmitter 54 to receiver 56. The physical characteristics of the wireless path are also subject to variations due to changes such as environmental conditions. As in the previous example, if the conditions change after the peak cell rate has been negotiated the virtual destination will not be able to transmit data across the wireless link if the data is shaped to UBR. Under ABR shaping the new permitted transport rate is returned to the source (not shown) in order to avoid congestion at virtual destination 50.

Figure 8 is a high level diagram representing an inverse multiplexing over ATM (IMA) configuration. In this example, traffic from virtual destination 50 to actual destination 56 is shared by virtual channel connections 58. Inverse multiplexing occurs at destination 56. A UBR connection between virtual destination 50 and destination 56 will carry traffic at the negotiated rate at connection setup. If one of the intermediate paths 58 is lost or

temporarily interrupted, the remaining virtual channel connections will be called on to carry that portion of the traffic which was previously carried by the interrupted connection. This may result in an inability to transport data at the negotiated rate, again resulting in congestion. If the traffic is shaped to ABR category of service, however, the need to share a greater transport rate will be recorded in the resource management cell and the send rate from the source revised accordingly.

Embodiments of the invention described above include an ATM network interconnecting the two end-systems. However, it is noted that the invention may be readily applied to any data communications networking technology implementing a class of service providing an explicit rate flow control. An explicit rate flow control specifies the particular rate at which a network connection may carry data traffic. Frame relay and Internet Protocol may some day offer various classes of service and explicit rate based service similar to ATM's ABR.

Although certain embodiments of the present invention have been described and illustrated it will be apparent to one skilled in the art that other changes can be made to the basic concept. It is to be understood, however, that such changes will fall within the scope of the invention as

defined by the appended claims.

Claims:

1. In a communications network for the transport of data between a source and a destination over a path which includes a transmission link having a transport rate which is subject to variations as a function of time, a method of managing data traffic through the network, the method comprising:

shaping a data connection from the source to the available bit rate (ABR) category of service, the ABR connection including integrated resource management (RM) cells for carrying congestion information back to said source over a feedback path;

monitoring dynamically the physical layer transmission rate of said link and recording said rate in said RM cell;

returning said RM cell including the recorded dynamic transport rate of said transmission link to said source; and adjusting the send rate of said source in accordance with said transport rate information.

2. A method as defined in claim 1 wherein said transmission link is an asymmetric digital subscriber loop (ADSL).

3. A method as defined in claim 2 wherein data between said source and said destination is bi-directional.

4. A method as defined in claim 3 wherein data between said destination and said source for at least part of said ATM path is shaped to comply with ATM unspecified bit rate (UBR) category of service.

5. A method as defined in claim 1 wherein said transmission link is a wireless path.

6. A method as defined in claim 1 wherein said transmission link is a path for inverted multiplexing over ATM (IMA).

7. A system for managing data traffic between a source and a destination over an ATM path, the ATM path including a transmission link having a dynamically variable transport rate, said system comprising:

shaping means in said source to shape said data traffic connection to comply with ATM available bit rate (ABR) category of service, said ABR connection including an integrated resource management (RM) cell for returning explicit rate (ER) congestion information to said source over a feedback path;

monitoring means associated with said transmission link to monitor dynamically transport rate capability of said transmission link;

recording means in said monitoring means to record said transport rate capability in said RM cell; and

control means in said source to change the send rate of said data traffic in accordance with said transport rate information.

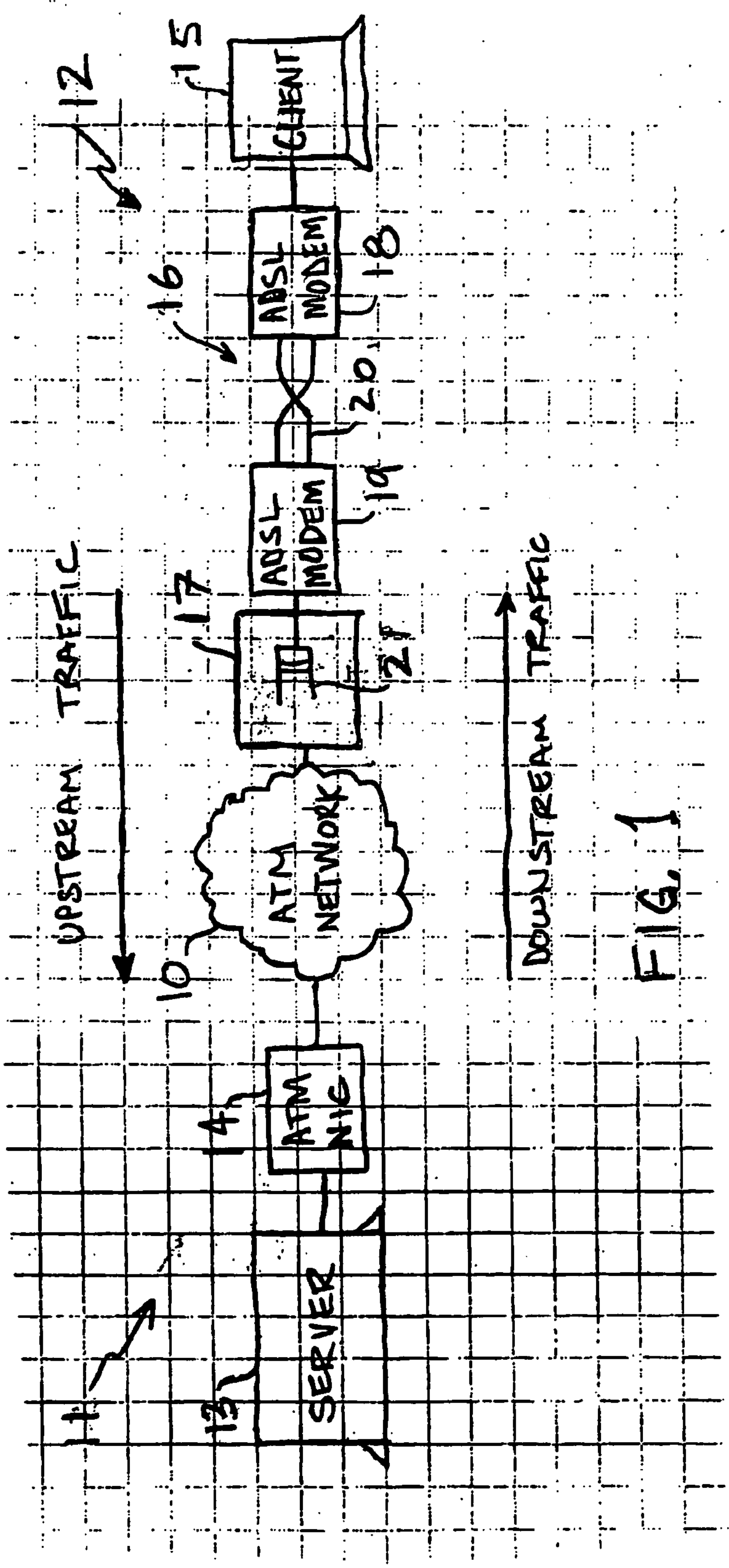

FIG. 1

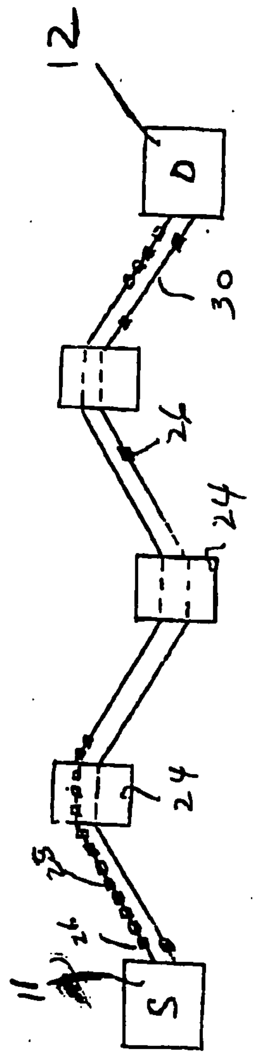

FIGURE 2

Marks & Clerk

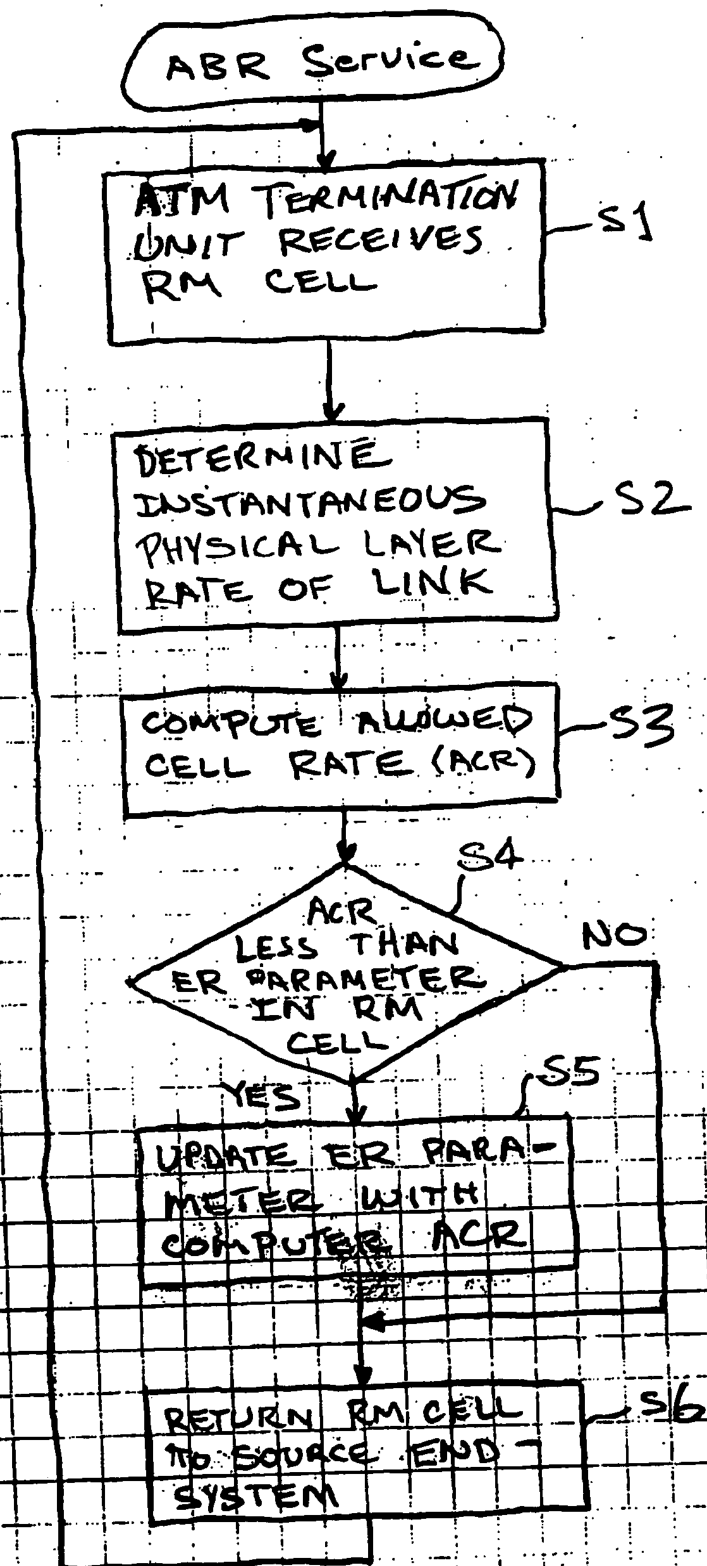

FIG. 3

Marks & Clerk

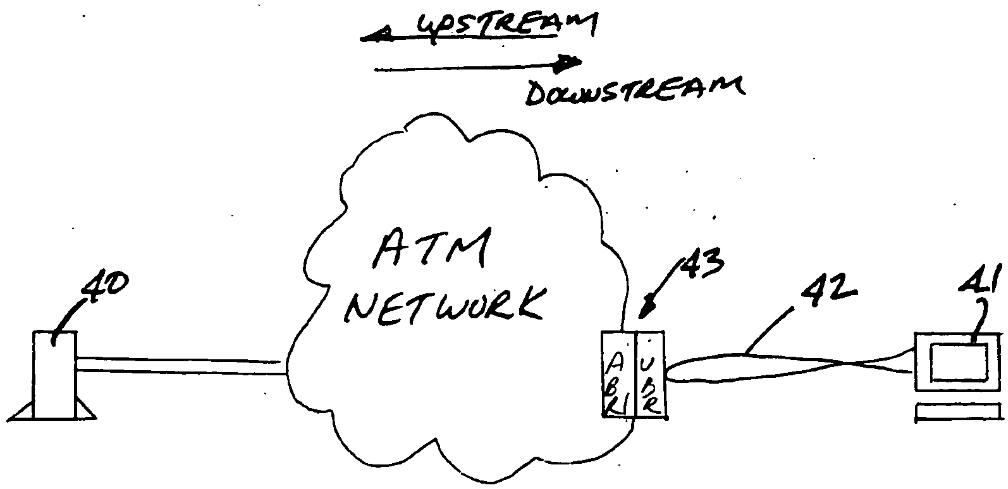

FIGURE 4

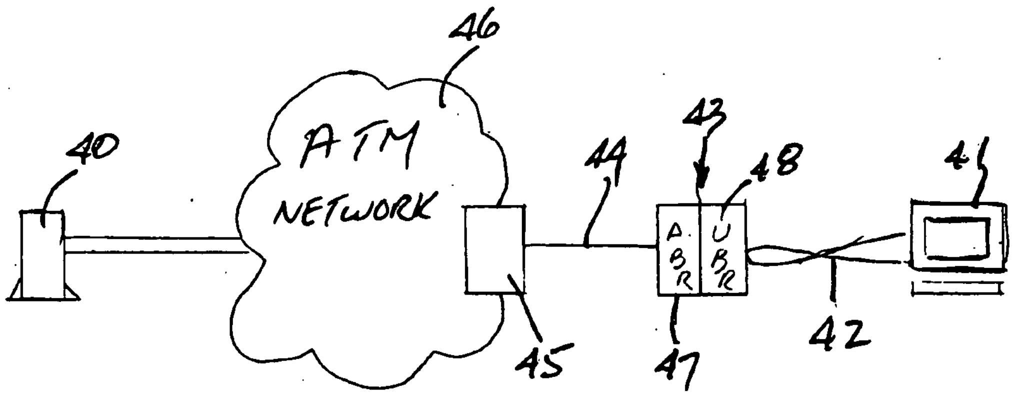

FIGURE 5

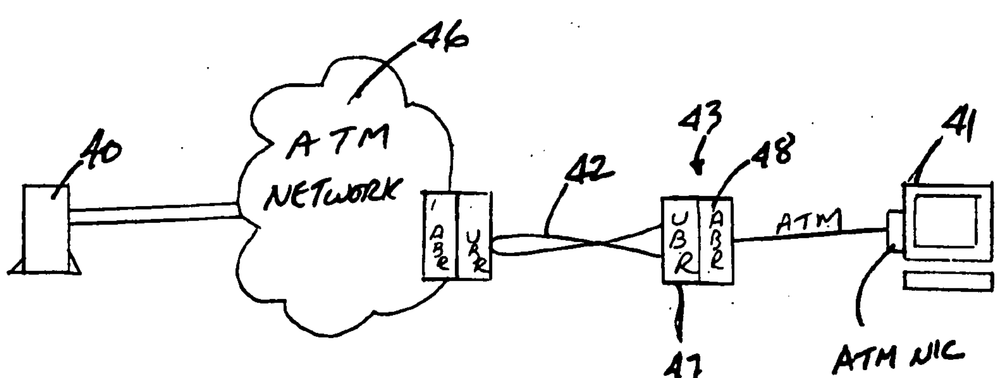

FIGURE 6

Marks & Clerk

CA 02222934 1997-11-28

FIGURE 7

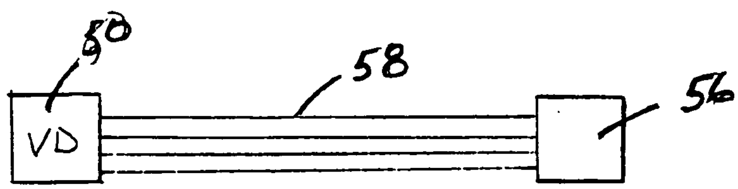

FIGURE 8

Marks & Clerk